ADMINISTRATIVE INFORMATION

1. **Project Name:** Multifunctional Metallic and Refractory Materials for Energy Efficient Handling of Molten Metals

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5. **Date Project Initiated:** March 1, 2004

6. **Expected Completion Date:** February 28, 2007

PROJECT RATIONALE AND STRATEGY

7. Project Objective:

The project goal is to extend the molten metal containment and submerged hardware life by an order of magnitude and improve the thermal efficiency with energy savings of 333 trillion BTU/year and cost savings of approximately $1 billion/year by 2020.

8. **Technical Barrier(s) Being Addressed:** (Please provide a brief paragraph describing the barrier to industrial energy efficiency that is being addressed by this project and the associated technical challenges.)

Containment of liquid metals during melting, recycling, and transfer processes in the aluminum, steel, and metal casting industries can lead to significant corrosion and wear or abrasion of the refractories in contact with the molten metal and slag. The corrosion and wear of the refractories result in contamination of the melt and failure of the refractory with energy loss through the containment walls and eventual attack of the container walls. The submerged hardware (sink and stabilizing rolls) are subject to aggressive attack in the molten bath. Subsequently, the submerged hardware requires its replacement in one to three weeks with significant loss of energy from down time and product quality during the change over process.

9. **Project Pathway:** (Please provide a one-paragraph summary of the approach, or pathway, being used to address the barrier(s). Emphasize the overall strategic approach for the project, not individual R&D tasks.)

Due to the complex interaction between the various modes that are simultaneously occurring in the material processes involving molten metal usage, the project team has identified five major areas of emphasis which most efficiently lead to the achievement of the stated objective. These major pathways include (1) identification of mechanisms by which failure occurs in the hardware for each individual situation; (2) development of a comprehensive dynamic corrosion model for molten materials handling; (3) development of a thermal management scheme associated with the refractories used for molten metal material handling; (4) development of a systematic approach based on computational analysis and experimental data for design of materials and/or surface treatment/coating systems to enhance the life of molten metal containing and handling hardware by an order of magnitude and to improve the thermal management efficiency of the molten material containment materials; and (5) preparation of identified alloys, refractory, surface treatment/coating, and the determination of corrosion, wear, thermal properties, and mechanical properties under laboratory and production conditions.

10. **Critical Metrics:** (Please describe the application-specific metric(s) (i.e., metrics in the end-use industrial process) that will be used to determine the success of the project.)

The baseline metric for success or failure in this project is to significantly improve the thermal management in aluminum, steel, and metal casting industries and extend the service lives and performance of molten metal containment materials and submerged pot hardware through novel material design, fabrication, and implementation. The result of demonstrably extended service lives and more efficient insulation will be significant energy savings. Realization of the project objective

of one order of magnitude service life extension will be achieved if the innovations resulting from the investigators' claims can be verified in both the laboratory and industrial level.

PROJECT PLANS AND PROGRESS

11. **Past Accomplishments:** (Please summarize the major accomplishments and key milestones achieved to date.)

- **Task 1**: Survey and assessment of current industrial materials and processes relating to containment of molten metals and submerged pot hardware – finished:9/30/04
- **Task 2.1**: Testing of current refractory materials, consisting of lab scale, prototype scale, thermal conductivity, and post mortem analysis
  - **Cup Testing has begun on provided current refractory materials**. Completed some post mortems and reported results.
- **Task 2.2**: Testing of current pot hardware materials, consisting of lab scale, prototype scale, thermal conductivity, and post mortem analysis
  – Current hot-dipping roll materials, including 316L steel and various WC-Co thermal spray coatings, have been shipped to industrial partners, and the testing is ongoing. Post mortem analysis will be carried out after the samples are shipped back to WVU
- **Task 3.1:** Dynamic corrosion model for refractory materials – Not Started
- **Task 3.2:** Dynamic corrosion model for hardware materials
  – Ongoing, the preliminary results of the dynamic model will be reported in semi-annual review meeting in Morgantown (05/24/05) and DoE project review meeting in Chicago (06/01/05)
- **Task 4.1:** Thermodynamic calculations for hardware and refractory materials
  - **Thermodynamic calculations for formation of corrosion products has begun based on chemistry of aluminum alloy and provided refractory materials.**
- **Task 4.2** Thermodynamic calculations for hardware materials
  – Thermodynamic calculations for dross formation and growth in hot-dipping baths are ongoing. The preliminary results of the dynamic model will be reported in semi-annual review meeting in Morgantown (05/24/05) and DoE project review meeting in Chicago (06/01/05)
- **Task 5.1** Identify new hardware and refractory materials
  - **Materials based on micronized kyanite as a substitute for fumed silica are being developed for testing.**
- **Task 5.2** Identify new hardware materials
  – New Al-overlay has been developed by ORNL. Preliminary corrosion test shows potential of the new overlay as the candidate of next generation hot-dipping rolls.
- **Task 6.1** Test new refractory materials
  - **Testing 99% alumina and 90% alumina 10% zirconia as new refractory materials wit near zero silica content.**
- **Task 6.2** Test new hardware materials
  – Newly developed Al-overlay samples for lab-scale dynamic and in-plant tests are being prepared by ORNL. The tests will start as soon as WVU receives samples.
- **Task 8** Energy assessment
  – Energy assessment of three hot-dipping lines, including Galv-tech, Wheeling-Nisshin, and California Steel, has been carried out by WVU

12. Future Plans:

- Testing of current materials, consisting of lab scale, prototype scale, thermal conductivity, and post mortem analysis of various existing refractory and hardware materials – Planned completion: 9/30/05
- Dynamic corrosion model for hardware and refractory materials – Planned completion: 2/28/06
- Thermodynamic calculations for hardware and refractory materials – Planned completion: 2/28/06
- Identify new hardware and refractory materials – Planned completion: 9/30/05
- Test new hardware and refractory materials – Planned completion: 2/28/06
- Component testing of candidate materials – Planned completion: 1/30/07
- Energy assessment of new components implemented at various industrial sites – Planned completion: 2/28/07
- Synthesis of all data – Planned completion: 2/28/07

13. **Project Changes:**

New Partners: Nucor Steel – Crawfordsville, Nucor Steel – Berkeley

14. **Commercialization Potential, Plans, and Activities:**

This project is unique in the sense that there is a technology pull from industry, as opposed to a technology push from academia and research organizations. The willingness of the project partners to fabricate and test the investigators findings is vital to the achievement of the stated project objectives. This cooperative effort will be of mutual benefit to industry and academia by enabling the investigators to focus on advancements that can be brought to the commercial market. Since the primary focus of this project is to improve existing components of established aluminum, steel, and metal casting processes, the benefits to the manufacturers can be easily implemented. It is anticipated that the participating companies, users, and producers will not have to pay any licensing from inventions resulting from this effort.

15. **Patents, Publications, Presentations:** (Please list number and reference, if applicable. If more than 10, please list only 10 most recent.)

None to date.